

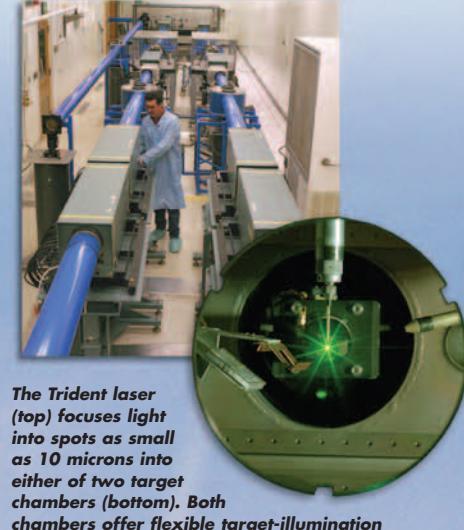
# Trident Laser Laboratory

## Terawatts of Power in a Microscopic Spot

Commissioned in 1993, the Trident Laser Laboratory supports experiments that require high-energy pulses of laser light. Trident's centerpiece is a neodymium-glass laser driver capable of firing three different beams. Complementing this driver are high-vacuum target chambers, an optical and x-ray diagnostics suite, and ancillary equipment and facilities.

More than a dozen national laboratories and universities have conducted about 200 experimental campaigns at Trident. These experiments include generating plasmas, x-rays, ion beams, and shock waves in solids and gases, and studying their properties.

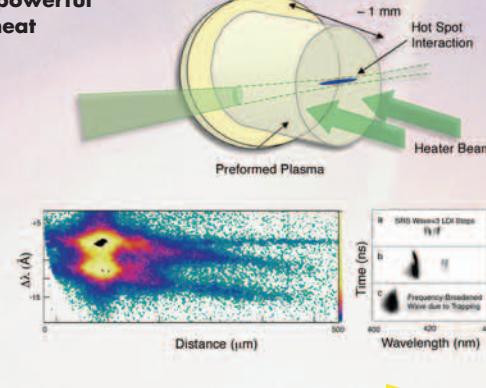
Trident creates pulses whose power is often comparable to that produced by all the electrical power plants in the United States. Such power—focused into a microscopic spot—enables scientists to study high-energy-density physics for stockpile stewardship, inertial confinement fusion (ICF), and basic research.



The Trident laser (top) focuses light into spots as small as 10 microns into either of two target chambers (bottom). Both chambers offer flexible target-illumination geometry and diagnostic placement, allowing a wide range of experiments to be fielded.

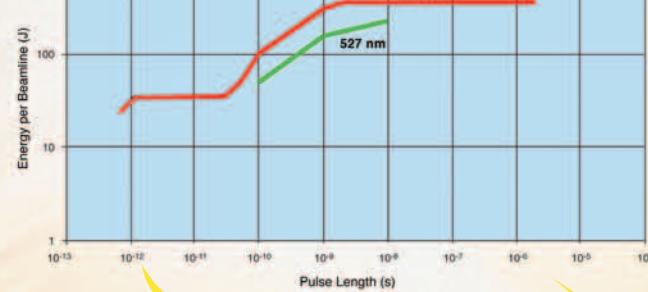
## Harnessing the Power of the Sun

Using Trident and other large lasers around the world, scientists are trying to create man-made "suns" by ICF. In nature, suns generate fusion energy by heating and confining hydrogen with the help of gravity. ICF would use powerful laser beams to compress and heat hydrogen fuel to fusion temperatures; the inertia of the fuel itself confines it long enough for fusion to occur. ICF contributes to stockpile stewardship by testing weapons materials and designs. It also could lead to the development of clean nuclear-fusion reactors, thus eliminating the need for conventional nuclear power plants and their long-lived waste products.

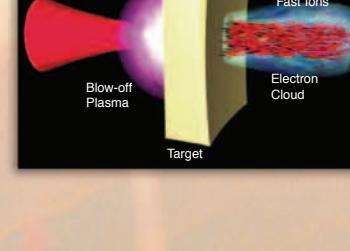


ICF seeks to compress and heat low-Z plasmas to fusion ignition conditions with lasers. But interaction of intense laser light with plasma produces enormously complex instabilities and energy flows—a fruitful field of scientific inquiry. In one set of experiments (top), two of Trident's beams create and heat plasma. The third beam then creates a single, well-defined interaction region within the plasma. This region generates plasma waves (bottom left and right).

**Not limited to just ICF,** Trident is unusually flexible because its pulse length can be varied more than six orders of magnitude—from less than a picosecond to more than a microsecond. Such flexibility enables access to a wide range of physical regimes.



In this experiment, an energetic and tightly focused subpicosecond pulse (right) from Trident's laser creates and accelerates relativistic electrons through a target. The resultant 1-MV  $\mu\text{m}^{-1}$  Coulomb field creates a virtual cathode, which in turn produces fast ions with the lowest transverse emittance ever observed. These ions can be used for radiographing objects, transporting energy into ICF targets, and studying physics processes important in weapons. In early 2004, Trident is the highest-energy subpicosecond laser in the United States.



At the other end of its operating range, Trident fires a microsecond pulse that drives a miniature (8 millimeters in diameter) flyer plate into a target at high velocity (graph), yielding shock and spall data about the target material. Such experiments support stockpile stewardship and basic materials research (determining properties such as dynamic yield strengths, elastic constants, and plasticity effects).

